

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.

aQK627
.M44C64
1995

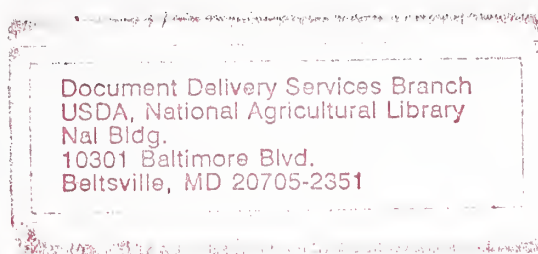
**United States
Department of
Agriculture**



National Agricultural Library

Revision 10/25/95

Melampsora species: An Evaluation of Quarantine
Status and Potential Pest Risk to U. S. Commodities



Prepared for APHIS PPQ BATS

By

Sue Cohen
USDA APHIS PPD, 3C39
4700 River Road, Unit #117
Riverdale, Maryland 20737

Table of Contents

I.	Introduction	3
II.	Background	4
III.	Taxonomy	7
IV.	Host Preferences	9
V.	U. S. and Worldwide Distribution of <i>Melampsora</i> species	14
VI.	Recommendations	22
VIII.	Reference	25

I. Introduction

USDA-APHIS-PPQ-BATS has requested support from USDA-APHIS-PPD to prepare pest risk assessments using a modified enhanced hazard identification approach for the purpose of re-examining the quarantine status of plant pathogenic fungi listed on the quarantine pest list. This pest risk assessment report is prepared in response to this request for assistance from USDA-APHIS-PPQ-BATS. USDA-APHIS-PPQ-BATS determined that the initial pest risk assessments should focus on those plant pathogenic fungi causing rust diseases. This pest risk assessment report will cover *Melampsora* species responsible for rust diseases of flax, euphorbia, nursery and forest trees.



II. Background

Fungal species of the *Melampsora* genus belong to the order Uredinales of the class Basidiomycetes and are included in the group called rust fungi. Rust fungi are known to cause orange, yellow or white colored infections on leaves, stems or floral parts. Most rust fungi are generally considered to be obligate parasites although occasionally some rust fungi have been cultivated on artificial media. Rust fungi tend to be specialized parasites and infect only certain host genera. Special forms of the fungi (*forma speciales*) cause disease in different host general and special forms can develop as physiologic or pathogenic races that infect only certain varieties within a plant species. Life cycles of rust fungi are based on production of spore types on plant hosts (Table 1) (Littlefield, 1981). There are three basic types of life cycles 1) macrocyclic -- when all spore types are present; 2) demicyclic – when the uredinial stage is absent; 3) microcyclic—when only the pycnial and telial or just the telial stages are present (basidiospores can reinfect the host in all microcyclic rusts).

Table 1. Stages of the complete life cycle of rust fungi (Littlefield, 1981)

Spore	Spore Structures	Spore Stages	Nuclear Condition
Basidiospore	Basidium (s.)	None	1N
	Basidia (pl.)		
Pycniospore	Pycnium (s.)	0	1N
	Pycnia (pl.)		
Aeciospore	Aecium (s.)	I	N+N
	Aecia (pl.)		
Urediniospore	Uredium (s.)	II	N+N
	Uredinia (pl.)		
Teliospore	Telium (s.)	III	N+N→2N—1N* ¹

¹ Nuclear fusion and meiosis typically accompany germination of teliospores.

Fungal rust diseases may also be distinguished by the requirement of one or two plant hosts for completion of the life cycle. Rusts completing a life cycle on one host species are termed autoecious. Examples of such rusts are *Phragmidium spp.* on rose, *Melampsora lini* on flax and *Uromyces phaseoli* on bean. Those rusts requiring two hosts for the completion of the life cycle are called heteroecious. For examples, *Melampsora medusae*, forms pycnidia and aecia on larch but its uredinia and telia are produced on poplar or cottonwood. The host species of heteroecious rusts are always drawn from different taxonomic groups. The rust fungus may alternate between ferns and conifers, gymnosperms and angiosperms or monocots and dicots. The term “alternate” host is used to refer to either of the two unlike hosts of a heteroecious rust but often it refers to the one of lesser economic importance. The pycnial/aecial or the uredinial/telial state host may represent the “alternate” host in the rust life cycle.

Ziller (1974) describes the host-alternating life cycle of *Melampsora* in Canada “Balidiospores from telial hosts (ex. *Populus* or *Salix* spp.) infect aecial hosts in the spring, and aecia (preceded by spermogonia—pycnia) appear on the aecial hosts approximately 2 weeks after infection. The aeciospores infect the telial hosts in the summer and uredinia appear on them approximately 2 weeks after infection. The urediniospores serve to spread and intensify the rust on its telial hosts, by producing more urediniospores which cause more infections of telial hosts during the summer. Toward fall, telial, instead of uredinia, develop on the telial hosts. The telia overwinter in a state of dormancy in the dead leaves on the ground and germinate the following spring, at the time when the new shoots of the aecial hosts begin to break forth from their buds. The release of basidiospores from these germinating teliospores marks the end of the 1-year life cycle of host-alternating *Melampsora* rusts of Canada”. Not all *Melampsora* species follow this life cycle pattern. Some species such as *Melampsora lini*, flax rust are autoecious completing a life cycle on one host, *Linum*. Appearance of new strains and races is quite common in *Melampsora* species (*M. lini*, *M. larici-populina*). Some species have adapted to climatic limits by reverting to a microcyclic life cycle. A microcyclic

life cycle species does not depend on sexual reproduction for genetic recombination. Instead, genetic recombination is achieved through hyphal fusion and nuclear exchange (*M. hirculi*).

The European and Mediterranean Plant Protection Organization considers two *Melampsora* species, *M. farlowii* (leaf and twig rust) on *Tsuga* and *M. medusae* (poplar leaf rust) on *Populus* to be significant quarantine pests. *M. farlowii* is considered to be a significant threat to the *Tsuga* nursery industry and *M. medusae* is a threat because of its swift spread among poplar plantations. *M. medusae* is of immediate concern because it is the only poplar rust of the European species known to spread without an alternate host (CABI/EPPO, 1992).

Ziller (1974) considers *M. medusae* and *M. occidentalis* to be significant threats to the coniferous nursery industry in Canada. To stem the spread of the rusts, Ziller (1974) recommends not planting Lombardy Poplars nearby any commercial nurseries. The Lombardy Poplars serve as a reservoir and pathway for spread of the *Melampsora* tree rust diseases.

III. Taxonomy

Rust fungi families are classified on the basis of telial morphology. More recently, Hiratsuka and Cummins (1963) questions the reliance on telial morphology and redescribed 11 families based on spermogonial (pycnia structure. Cummins and Hiratsuka (1983) proposed 14 families of which one is called Melampsoraceae Shroeter. The characteristics of this family are spermogonia type 2 or 3 of Group I, aecial state *Caeoma* with rudimentary or no peridium and catenulate verrucose spores. Uredinia with abundant capitate paraphyses, urediniospores borne singly, echinulate, pores scattered or bizonate. Telia are considered epidermal or rarely subcuticular. Species are heteroecious or autoecious and most species are macrocyclic.

Littlefield (1981) reports that some 80 northern temperate, autoecious or heteroecious species of this genus have been described. The major characteristic of the *Melampsora* genus is the subepidermal crust of sessile, laterally adherent, single-celled teliospores that forms near the surface of the infected host. Browne and Laurie (1968) described 30 species of *Melampsora* which attack forest and plantation trees.

Kaneko and Hiratsuka (1984) examined Melampsoraceous rust species for morphological characters to be used at the species level for taxonomic classification. They proposed the following characters of urediniospore germ pores, basidiospores and isolated teliospores ("free teliospores") in uredinia for species identification. These researchers recognized five arrangements of germ pores (bizonate, polar, scattered, equatorial and superequatorial) in urediniospores. Kaneko and Hiratsuka also observed globoid basidiospores and one to three celled teliospores in *Melampsora* species.

Yamaoka and katsuya (1985) suggested other morphological characters besides teliospore morphology and host range could be used to separate *Melampsora* species. They examined 27 isolate of *Melampsora spp.* and *Melampsondium betulinum* grown on artificial media and host plants. They concluded that urediospore size, paraphysis, ostiolar cell shape and teliospore apical wall thickness were stable enough characters to consider for taxonomic purposes. Unstable characters were urediospore shape, wall thickness, size and wall thickness of paraphyses, size of ostiolar cells and shape and size of teliospores.

IV. Host Preferences

Cummins and Hiratsuka (1983) state that *Melampsora* species belong to the host-restricted heteroecious rust group but go on to explain that this genus is composed of heteroecious and autoecious species. The heteroecious species produce telia on willows or poplars. Many of these species produce aecia on fir, Douglas fir, or larch but other parasitize *Ribe*, *saxifraga*, or *Allium*. The autoecious species are not host restricted.

Browne and Laurie (1968) describe 30 species which attack plantation and forest trees (Table 2). Of the 30 species listed, the aecial and telial host genera differ for the heteroecious rusts. Farr et al. (1989) describe additional species which attack *Euphorbia*, *Ribes*, *Hypericum* and *Linum* (Table 3).

Table 2. Melampsora species known to attack forest and plantation trees (Browne and Laurie, 1968)

Species	Aecial Host	Telial Host
<i>M. abieti-capraearum</i> Tubeuf.	<i>Abies</i>	<i>Salix</i>
<i>M. abietis-canadensis</i> (Farl). Arth.	Pinaceae	Salicaceae
<i>M. aecidioides</i> Schroet	Syn. <i>M. populnea</i>	
<i>M. albertensis</i> Arth.	Syn. <i>Medusae</i>	
<i>M. allii-fragilis</i> Kleb.	<i>Allium</i>	<i>Salix</i>
<i>M. allii-salicis-albae</i> Kleb.	Allium, Arum	<i>Populus</i>
<i>M. amygdalinae</i> Kleb.	<i>Salix</i>	<i>Salix</i>
<i>M. ciliata</i> Barclay	<i>Populus ciliata</i>	<i>Populus ciliata</i>
<i>M. epitea</i> Thum.	<i>Euonymous, Ribes, Abies, Laris, Tsuga, Saxifraga</i>	<i>Salix</i>
<i>M. evonymi-carraearum</i> Kleb.	Syn. <i>M. epitea</i>	
<i>M. farlowii</i> (Arth.) Davis	<i>Tsuga</i>	<i>Tsuga</i>
<i>M. larici-capraearum</i> Kleb.	Syn. <i>M. capraearum</i>	
<i>M. larici-pentandrae</i> Kleb.	Syn. <i>M. epitea</i>	
<i>M. larici-pentandrae</i> Kleb.	<i>Larix</i>	<i>Salix</i>
<i>M. larici-populina</i> Kleb.	<i>Larix</i>	<i>Populus</i>
<i>M. larici-tremulae</i> Kleb.	Syn. <i>M. populnea</i>	
<i>M. medusae</i> Thum.	<i>Larix</i>	<i>Populus</i>
<i>M. oblonga</i> Bagchee.	<i>Pinus griffithii</i>	<i>Pinus griffithii</i>

<i>M. occidentalis</i> Jacks	<i>Pseudostuga, Abies, Larix, Picea, Pinus</i>	<i>Populus</i>
<i>M. paradoxa</i> Diet. And Holw.	<i>Larix</i>	<i>Salix</i>
<i>M. pinitorqua</i> Rostrup.	Syn. <i>M. populnea</i>	
<i>M. populnea</i> (Pers.) Karst.	<i>Larix, Mercuris, Pinus</i>	<i>Populus</i>
<i>M. ribesii-purpureae</i> Kleb.	Syn. <i>M. epitea</i>	
<i>M. ribesii viminalis</i> Kleb.	<i>Ribes</i>	<i>Salix</i>
<i>M. rostrupii</i> auct.	Syn. <i>M. populnea</i>	
<i>M. salicis-albae</i> Kleb.	<i>Allium</i>	<i>Salix</i>
<i>M. tremulae</i> Tul.	Syn. <i>M. populnea</i>	

Table 3. USDA-ARS Fungi on Plants and Plant Products lists the following species with their respective hosts in the U. S. (Farr et al., 1989)

Species	Hosts
<i>M. alieti-capraearum</i> Tub. syn. <i>M. Americana</i> syn. <i>M. humboldtiana</i>	<i>Abies, Salix</i>
<i>M. abietis-canadensis</i> C. A. Ludw. Ex Arth.Syn. <i>Caeoma abietis-canadensis</i>	<i>Populus, Tsuga</i>
<i>M. artica</i> Rostr.	<i>Salix, Saxifraga</i>
<i>M. cumminsii</i> Bagyanarayana & Ramachar	<i>Populus</i>
<i>M. epitea</i> Thum.	<i>Abies, Larix, Ribes, Salix, Tsuga</i>
<i>M. epitea</i> Thum. F. sp. Tsugae Ziller syn. <i>Caeoma dubium</i>	<i>Tsuga</i>
<i>M. euphorbiae</i> Castagne	<i>Euphorbia</i>
<i>M. euphorbiae-gerardiana</i> W. Muell. Stettin.	<i>Euphorbia</i>
<i>M. farlowii</i> (Arth.) J. J. Davis syn. <i>Mecium farlowii</i>	<i>Tsuga</i>
<i>M. hypericorum</i> G. Wint. In rabehn. syn. <i>Mesopsora hypericorum</i> syn. <i>Uredo hypericorum</i> (anamorph)	<i>Hypericum</i>
<i>M. lini</i> (ehrenb.) desmaz. syn. <i>Melampsora lini</i> var. <i>liniperda</i>	<i>Linum</i>
<i>M. medusae</i> Theum. syn. <i>Melampsora albertensis</i> sn. <i>Caeoma faullinana</i>	<i>Abies, Larix, Populus, Pseudotsuga</i>
<i>M. monticola</i> Mains	<i>Euphorbia</i>
<i>M. occientantalis</i> H. Jacks	<i>Populus, Psudotsuga</i>
<i>M. paradoxa</i> Dietel & Holw. In Dietel. syn. <i>Melampsora bieglowii</i>	<i>Larix, Salix</i>
<i>M. populnea</i> (Pers.) P. Karst Syn. <i>Melampsora aecidioides</i>	<i>Populus</i>
<i>M. ribesii-purpureae</i> Kleb. In Pringsh. syn. <i>Melampsora confluens</i>	<i>Ribes, Salix</i>

V. United States and Worldwide Distribution of *Melampsora* species

Melampsora species are well distributed among the Western and Eastern Hemispheres. Littlefield estimates that there are over 80 species in this genus. Seventeen species are known to cause damage in the United States (Farr et al. 1989) in the United States. For example, *Melampsora line, flax rust*, has become widespread in Canada and the northern United States due to the cultural practice of continuing to plant susceptible flax varieties. Nineteen new races of the pathogen were identified from 1974 to 1975 field collections (Hoes and Zimmer, 1976). These new races were presumed to arise due to natural hybridization in the flax fields.

Movement of infected plantings to new area can also easily spread these rust species. For example, *Melampsora occidentalis* on black cottonwood (*Populus trichocarpa*) is indigenous to western N. America. More recently, experimental plantings of *P. trichocarpa* have been established in the Midwest. This leaf rust was found in Iowa in 1989 and 1990 and in Wisconsin in 1989, 1990 and 1991. Moltazan et al. (1993) now consider it established in the Central United States.

Distribution of these species is also enhanced by the presence of aecial hosts. For example, Newcombe et al. (1994) reported that in 1991 two poplar leaf rusts (*M. larici-populina* and *M. medusae f. sp. Deltoidae*) were discovered for the first time in the Pacific Northwest. *M. larici-populina* had a reported aecial host range of four conifer species and *M. medusae f. sp. Deltoidae* had a reported aecial host range of two conifer species. Newcombe et al. (1994) determined that *M. larici-populina* could infect two other conifer hosts, *Pinus ponderosa* and *P. contorta* and that *M. medusae f. sp. Deltoidae* could infect five additional hosts.

The appearance of new races after an exotic pest introduction was addressed by Pinon 1994 when researching the distribution of *melampsora larici-populina* races in California and Washington. Pinon reported that *Melampsora larici-populina* has been found in 18 counties of California. He collected uredinia from two separate locations in

California, one location in Washington and used a set of poplar differentials for testing race identification. Pinon determined that race E1 is dominant in both California and Washington but that three other unnamed races exist in low abundance. Races E2 and E3 were not found in any of the locations tests.

New hosts of *Melampsora* species are frequently described in the literature (particularly for the autoecious species). For example, from south-east Spain, *Melampsora euphorbiae* was reported on *Euphorbia lagascae* to be a new major pathogen. Heretofore, this species did not attack this host. Villalobos and Jellis 1992 describes this plant host as a spurge native to southeast Spain and economically important because of its high seed oil content rich in vemicolic acid.

Several *Melampsora* species may survive in the absence of a coniferous host by persisting and spreading to other hardwoods via urediniospores. Some species in cold climates can do without the coniferous host as well by persisting on two angiospermous hosts (Savile, 1953; USDA-Forest Service, 1991.) Also, in the case of *M. hirculi*, this species relies on hyphal fusion and nuclear exchange to allow genetic recombination under colder climatic conditions after it switches to a microcyclic life cycle (Savile, 1979).

Table 4. Distribution of *Melampsora* species

Species	Distribution	Reference
<i>M. abieti-capraearum</i> Tubeuf.	W. Hemisphere, W. Europe	2,3
<i>M. abietis-canadensis</i> (Farl..) Arth.	N. North America	2
<i>M. aecidioides</i> Schroet	See syn. <i>M. populnea</i>	
<i>M. albertensis</i> Arth.	See syn. <i>M. medusae</i>	
<i>M. allii-fragilis</i> Kleb.	Europe	1
<i>M. allii-salicis-albae</i> Kleb.	See syn. <i>M. salicis-albae</i>	
<i>M. allii-populina</i> Kleb.	S. America, Europe, N. Africa, Near East	1
<i>M. amygdalinae</i> Kleb.	Europe	1
<i>M. artica</i> Rostr.	Circumboreal	2, 3
<i>M. bigelowii</i> Thum.	See syn. <i>M. paradoxa</i>	
<i>M. capraearum</i> Thum.	N. temperate zone of E. Hemisphere	1
<i>M. ciliata</i> Barclay	India and Pakistan	1
<i>M. cumminsii</i> Bagy & Rama	NH (Type)	2
<i>M. epitea</i> Thum.	Widespread in temperate regions	2
<i>M. epitea</i> Thum. <i>F.sp.tsugae</i> Ziller	Pacific Northwest	2, 3
<i>M. euphorbiae</i> Castagne	Widespread	2
<i>M. euphorbiae-gerardianae</i> W. Muell. Stettin.	C. and E. U.S., Asia, Europe	2
<i>M. evonymi-carraearum</i> Kleb.	See syn. <i>M. epitea</i>	
<i>M. fagi</i> Dietel & Neger	Chile	2
<i>M. farlowii</i> (Arth.) Davis	N. east United States	2, 4

Species	Distribution	Reference
<i>M. hirculi</i> Lindr.	Eastern Keewatin District, Canada	5
<i>M. hypericorum</i> G. Wint. In Rabenh.	W. United States	2
<i>M. larici-capraearum</i> Kleb.	See syn. <i>M. apraeearum</i>	
<i>M. larici-epitea</i> Kleb.	See syn. <i>M. epitea</i>	
<i>M. larici-pentandrae</i> Kleb.	N. temperate zone of E. Hemisphere	1
<i>M. larici-populina</i> Kleb.	S. America, N. temperate zone of E. Hemisphere	1, 6
<i>M. larici-tremulae</i> Kleb.	See syn. <i>M. populnea</i>	
<i>M. lini</i> (Ehrenb.) Desmaz	Cosmopolitan	2, 7
<i>M. medusae</i> Thum.	N. America, Argentina, Australia, Japan, Africa	2, 3, 4, 8, 11
<i>M. monticola</i> Mains.	C. and W. North America	2
<i>M. oblonga</i> Bagchee.	India	1
<i>M. occidentalis</i> Jacks	W. N. America	2, 3
<i>M. paradoxa</i> Diet. And Holw.	N. North America	2, 3
<i>M. pinitorua</i> Rostrop	See syn. <i>M. populnea</i>	
<i>M. populnea</i> (Pers.) Karst.	W. U.S., rare in E. U.S., Europe, India	2
<i>M. ribesii-purpureae</i> Kleb. In Pringsh.	Temperate N. Hemisphere	2, 3
<i>M. ribesii-viminalis</i> Kleb.	Europe	1
<i>M. ricini</i> Noronha	Africa, Asia, Europe	9
<i>M. rost rupii</i> auct.	See syn. <i>M. populnea</i>	
<i>M. salicis-albae</i> Kleb	N. temperate zone of E. Hemisphere	1
<i>M. tremulae</i> Tul.	See syn. <i>M. populnea</i>	

References

1. Browne, F. G. and Laurie, M. V. 1968. Pests and Diseases of Forest Plantation Trees. Clarendon Press, Oxford.
2. Farr, D.F., Bills, G. F., Chamuris, G. P., and Rossman, A. Y. 1989. Fungi on Plants and Plant Products. American Phytopathological Society, St. Paul.
3. Ziller, W. G. 1974. The tree rusts of western Canada. Publication No. 1329. Forest Service, British Columbia, Canada.
4. CABI and EPPO. Quarantine Pests for Europe. 1992.
5. Savile, B. D. O. 1979. *Melampsora hirculi*. Fung. Canadenses No. 141 Ag. Canada.
6. Walker, J. 1975. *Melampsora larici-populina*. CMI Descriptions of Pathogenic Fungi and Bacteria No. 479. CAB International, Wallingford, UK.
7. Laundon, G. F. and Waterston, J. M. 1965. *Melampsora lini*. CMI Descriptions of Pathogenic Fungi and Bacteria No. 51. CAB international, Wallingford, UK.
8. Walker, J. 1975. *Melampsora mnedusae*. CMI Descriptions of pathogenic Fungi and Bacteria No. 480. CAB international, Wallingford, UK.
9. Punithalingam, E. 1968. *Melampsora ricini*. CMI Descriptions of Pathogenic Fungi and Bacteria No. 171. CAB international, Wallingford, UK.
10. CABI. 1992. *Melampsora ricini*. Distribution Maps of Plant Diseases. CAB International, Wallingford, UK.
11. Trench, T.N., Baxter, Ap. P., and Churchill, H. 1958. First report of *Melampsora medusae* on *Populus deltoides* in Africa. S. African Forestry Journal 144: 6-9.

VI. Enhanced Hazard Identification

A simplified version of the enhanced hazard identification process was adopted for this risk assessment and is based on a process designed by Richard Orr and Bob Griffin, PPD-PRAS for PPQ-BATS. This process will be referred to as the enhanced hazard risk assessment for determining the quarantine status of exotic organisms. This enhanced hazard process is composed of three criteria: 1) taxonomy, 2) pest distribution and 3) known importance of pest. Each criterium is ranked either high, medium or low risk based on data available on the organisms. If information is unknown in Criteria 2 and 3 the risk category is given unknown status. See table 5 or a full description of criteria and risk categories.

Table 5. Enhanced Hazard Criteria and Risk Categories

Criteria	Risk Definitions
Criteria 1 – Taxonomy	
High	Complete species or subspecies identification
Medium	Generic or higher level identification only and assessor feels comfortable extrapolating information from similar organisms.
Low	Generic or higher level identification only and assessor not comfortable extrapolating information from similar organisms.
Criteria 2 – Hazard Identification/Distribution of Taxon	
High	Non-indigenous and not present, but capable of establishment in the U.S., or Non-indigenous with limited range in the U.S., and identified as an APHIS program concern or has not been evaluated by APHIS; Or Non-indigenous, present in the U.S., and reached probable limits of range, but genetically different enough to warrant concern or vector of a foreign plant pest.

Medium	Native, but genetically different enough to warrant concern or to vector an exotic plant pest (that the original taxon could not), and is capable of further expansion or increased damage potential
Low	Non-indigenous or native in U.S. and reached probable limits of range and not genetically different enough to warrant concern and/or vector a foreign plant pest, or Has not reached probable limits of range, but no official quarantine exists or is likely to be initiated.
Unknown	Unknown, not enough information available to make a choice.

Criteria 3 = Agricultural Concern – known importance

High	Known pest or capable of vectoring known pests of agriculture (corps, forests, animals, beneficial organisms, environment, etc.)
Medium	Not known as a pest of agriculture, but having characteristics that demonstrate potential for becoming a pest in the U.S.
Low	Not know as pest of agriculture and not likely to become an agricultural pest if established in the U.S.
Unknown	Unknown, not enough information available to make a choice.

Table 6. Enhanced Hazard Risk Assessment

Species	Cri. 1	Cri. 2	Cri. 3	Summary Risk	Quarantine Decision
<i>M. abieti-capraearum</i>	H	L	H	HLH-Low	None
<i>M. abietis-canadensis</i>	H	L	H	HLH-Low	None
<i>M. artica</i>	H	L	H	HLH-Low	None
<i>M. cumminsii</i>	H	L	H	HLH-Low	None
<i>M. epitea</i>	H	L	H	HLH-Low	None
<i>M. epitea f. sp. Tsugae</i>	H	L	H	HLH-Low	None
<i>M. euphorbiae</i>	H	L	H	HLH-Low	None
<i>M. euphorbiae-gerardinae</i>	H	L	H	HLH-Low	None
<i>M. farlowii</i>	H	M	H	HMH-Med/High	Action
<i>M. hirculi</i>	H	H	H	HHH-High	Action
<i>M. hypericorum</i>	H	M	H	HMH-Med/High	Action
<i>M. larici-populina</i>	H	M	H	HMH-Med/High	Action
<i>M. lini</i>	H	M	H	HMH-Med/High	Action
<i>M. medusae</i>	H	M	H	HMH-Med/High	Action
<i>M. monticola</i>	H	M	H	HMH-Med/High	Action
<i>M. occidentalis</i>	H	M	H	HMH-Med/High	Action
<i>M. paradoxa</i>	H	M	H	HMH-Med/High	Action
<i>M. populnea</i>	M	H	H	MHH-Med/High	Action
<i>M. ribesii-purpurea</i>	H	L	H	HLH-Low	None
<i>M. ricini</i>	H	H	H	HHH-High	Action
<i>M. salicis-albae</i>	H	H	H	HHH-High	Action

VII. Recommendations

The high risk category rusts are *M. hirculi*, *M. ricini* and *M. salicis-albae*. These species are not reported in the U. S. *M. farlowii*, *M. hypericocum*, *M. larici-populina*, *M. lini*, *M. medusae*, *M. monticola*, *M. occidentalis*, *M. paradoxa*, *M. populnea* were rated in the medium risk category based on expected expansion of the pest in the U.S., development of new races, recent epidemics described overseas and ability to act in concern with another *Melampsora rust* species. The following *Melampsora* species were ranked in the low risk category: *M. abieti-capraearum*, *M. abietis-canadensis*, *M. artica*, *M. cumminsii*, *M. epitea*, *M. epitea* sp. Tsugae, *M. euphorbiae*, *M. euphorbiae-gerardinae*, and *M. ribesii-purpureae*.

Recently, Pei et al. (1995) discovered an unknown *Melampsora* species similar to *M. humilis* which infects stems and shoots of willow in the United Kingdom. The authors suggest that it overwinters in the shoots since it forms teliospores very poorly on leaves. This report suggest the *Melampsora* genus is highly adaptable and able to colonize different ecological niches.

Further refinement and higher certainty maybe achieved with this enhanced hazard identification process by re-evaluating with additional criteria. These criteria might include type of life cycle (macrocytic, microcytic, demicytic), heteroecious or autoecious pattern, races of f. sp. Strains, climate, and economic damage. However, this type of data may not be available for all *Melampsora* species evaluated.

Melampsora spp. and *Melampsora larici-populina* were recently ranked by the Forest Service in the Pest Risk Assessment on the Importation of Larch from Siberia and the Soviet Far East as well as the Pest Risk Assessment of *Pinus radiata* and Douglas-fir Logs from New Zealand. All *Melampsora* species from Siberia and the Soviet Far East were ranked high risk (*M. betulinum*, *M. larici-capraearum*, *M. larici-epitea*, *M. larici-populina*, *M. larici-tremulae* and *M. populnea*). *M. larici-populina* was given a moderate

risk in the New Zealand Pest Risk Assessment. *M. larici-populina* was also evaluated using the generic risk assessment process by Bob Schall, APHIS/PPQ/DEO. This rust species was determined to be in the high risk category.

The high risk species ranked in the enhanced hazard process in this report represent examples of limited distribution (*M. hirculi*-District in Canada), limited host range (*M. ncini*-restricted to castor bean), and diverse alternate hosts (*M. salicis-albae*-willow and onion). Since these species are only reported outside the U.S., these species are of concern. The U.S. Forest Service lists *M. betulinum*, *M. larici-capraearum*, *M. larici-epitea*, *M. larici-populina*, *M. larici-tremulae* and *M. populnea* as high risk pests of concern from Siberia and the Soviet Far East.

Melampsora species listed under medium to high risk category in the enhanced hazard process are typically U.S. species which have the potential for further expansion in the U.S. through movement of nursery stock. Many of these species have demonstrated the ability to produce new races in response to planting resistant host material. Also, reports indicate that several species in the medium to high risk group may be present on the same host and contribute to a synergistic infection reaction.

This genus contains species which may attack flax, onion, euphorb, poplar, Lombardy poplar, pine, doug-fir, larch, birch, hemlock and willow. A potential pathway of introduction and spread would be the nursery industry. Euphorb, Lombardy poplar, hemlock and pines are common at nurseries. Forest nurseries and plantations would also be another avenue of release or at risk to infection.

The identify of these species is also a continuing questions when assessing the pest risk. Many of the species differ slightly by morphological characters. Future efforts will have to resort to incorporating more modern molecular techniques during the identification process. Ayliffe et al. (1994) utilized random amplification of polymorphic DNA bands to distinguish genetic crosses of *M. lini* and validated the technique for further molecular studies of *M. lini*. Molecular techniques may also be useful in identifying a new strain as a species hybrid or a reported new species. Spiers and

Hopcroft (1994) reported on an interspecific hybrid produced by *M. medusae* and *M. larici-populina*. If this is the case, it could be confirmed by molecular methods. This situation could easily occur in the U.S. as both species have been found in close proximity on the same plant host.

There are an abundance of undescribed and unreported *Melampsora* strains in the world that pose a potential risk to U.S. forestry and nursery industry. Chastagner (1995) indicated that the newest area of undescribed strains is to be found in China. The most likely exotic strains will come in on poplar and will hosts from Europe, China, Japan, Australia or New Zealand.

VIII. References

- Ayliffe, M. A., Lawrence, G. J., Ellis, J. G. and Pryor, A. J. 1994. Heteroduplex molecules formed between allelic sequences cause nonparental RAPD bands. *Nucleic Acids Research* 22: 1632-1636.
- Brown, J. S. 1984. Recent invasions of Australia and New Zealand by pathogenic fungi and counter measures. *EPPO Bulletin* 14:417-428.
- Browne, F. G. and Laurie, M. V. 1968. *Pests and Diseases of Forest Plantation Trees*. Clarendon Press, Oxford.
- CABI. 1992. *Melampsora ricini*. Distribution Maps of Plant Diseases NO. 467. CAB International Mycological Institute.
- CABI. 1987. *Melampsora populnea* Distribution Maps of Plant Disease No. 389. CAB International Mycological Institute.
- Chastagner, G. 1995. Personal Communication
- Cummins, G. B. and Hiratsuka, Y. 1983. *Illustrated Genera of Rust Fungi*. American Phytopathological Society, St. Paul, MN.
- Farr, D. F., Bills, G. F., Chamuris, G. P., and Rosman, A. Y. 1989. *Fungi on Plants and Plant Products*. American Phytopathology Society, St. Paul.
- Hepting, G. H. 1971. *Diseases of forest and shade trees of the United States*. Agricultural Handbook No. 386. Forest Service, US Department of Agriculture.
- Hoes, J. A. and Zimmer, D. E. 1976. New North American races of flax rust, probably products of natural hybridization. *Plant Disease Reporter* 60:1010-1013.
- Kaneko, S. and N. Hiratsuka. 1984. Some criteria in taxonomy of melampsoraceous rust species. *Rep. Tottori Mycol. Inst.* 22:141-147.
- Laundon, G. F. and Waterston, J. M. 1965. *Melampsora lini*. CMI Descriptions of Pathogenic Fungi and Bacteria No. 51. CAB International, Wallingford, UK.
- Littlefield, L. J. 1981, *Biology of the Plant Rusts*. Iowa State University Press, Ames.
- Moltzan, B.D., Stack, R. W., and P.A. Mason. 1993. First report of *Melampsora occidentalis* on *Populus trichocarpa* in the Central United States. *Plant Disease* 77:953.

- Newcombe, G. and Chastagner, G. A. 1003. A leaf rust epidemic of hybrid poplar along the lower Columbia River caused by *Melampsora medusa*. Plant Disease 77:528-S31.
- Newcombe, G. and Chastagner, G. A. 1993. First report of the Eurasian poplar leaf rust fungus, *Melampsora larici-populina*, in North America.
- Newcombe, G. Chastagner, G.A. and McDonald, S.K. 1994. Additional coniferous aecial hosts of the poplar leaf rusts, *Melampsora larici-populina* and *M. medusae* f. sp. *Deltoideae*. Plant Disease 78:1218.
- Pei, M. H., Royle, Dj. J. and Hunter, T. 1995. A comparative study of stem-and leaf-infecting forms of *Melampsora* rust on *Salix viminalis* in the U.K. Mycol. Res. 3:357-363.
- Pinon, J., Newcombe, G., and Chastagner, G. 1994. Identification of races of *Melampsora larici-populina*, the Eurasian poplar leaf rust, on *Populus* species in California and Washington. Plant Disease 78:1011.
- Punithalingam, E. 1968. *Melampsora ricini*. CMI Descriptions of Pathogenic Fungi and Bacteria No. 171. CAB International, Wallingford, UK
- Savile, D.B.O. 1953. Short-season adaptations in the rust fungi. Mycologia 45:75-87.
- Savile, D.B.O. 1979. *Melampsora hirculi*. Fungi Canadenses No. 141. National Mycological Herbarium, Biosystematics Research Institute Research Branch, Agriculture Canada, Ottawa, Ontario.
- Schall, R. A. 1992. Pest risk analysis on larch-poplar rust. USDA/APHIS/PPD/DEO
- Spiers, A. G. and Hopcroft, D.H. 194. Comparative studies of the poplar rusts *Melampsora medusae*, *M. larici-populina* and their interspecific hybrid *M. medusae-populina*.
- USDA-Forest service. 1991. Pest risk assessment on the importation of larch from Siberia and the Soviet Far East. Miscellaneous Publication NO. 1495.
- USDA-Forest Service. 1992. Pest risk assessment of the importation of *Pinus radiata* and Douglas fir logs from New Zealand. Miscellaneous Publication No. 1508.
- Villalobos, M.J.P. and Jellis, G.J. 1992. Occurrence of *Melampsora euphorbiae* on *Euphorbia lagascae* in south-east Spain. Plant Pathology 41:370-371.
- Walker, J. 1975. *Melampsora larici-populina* CMI Descriptions of Pathogenic Fungi and Bacteria NO. 479. CAB International, Wallingford, UK.

- Walker, J. 1975 *Melampsora medusae*. CMI Descriptions of Pathogenic Fungi and Bacteria No. 480. CAB International, Wallingford, UK.
- Yamoaka, Y. and Katsuya, K. 1985. Evaluation of morphological characteristics in the rust taxonomy with special reference to the cultural state of *Melampsora* and *Melampsoridium*. Trans. Mycol. Soc. Japan 26:231-246.
- Yang, S.-M. , Zhuang, J.-Y., Lui, W.-J. 1993. Pathogens of leafy spurge in Inner Mongolia, China. Plant Disease 77:310.
- Ziller, W. G. 1974. The tree rusts of western Canada. Publication No. 1329. Forest Service, British Columbia, Canada.

NATIONAL AGRICULTURAL LIBRARY



1022594291

NATIONAL AGRICULTURAL LIBRARY



1022594291